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Perioperative infusion therapy with different volume protocols in patients with moderate surgical risk undergoing emergency laparotomy

Abstract. *To assess the effectiveness of the liberal and restrictive protocol of perioperative infusion therapy in emergency laparotomy, we examined 100 patients. The degree of surgical and anesthetic risk according to the ASA scale was IIE, the surgical risk on the POSSUM scale was 1–5 % and corresponded to the average surgical risk. All patients underwent preoperative preparation for 2 hours in the intensive care unit in the volume of 2870 ± 540 ml and 1733 ± 340 ml, respectively, in groups, with a calculated infusion load of 80–120 and 40–60 ml/kg/day. Patients were examined clinically, instrumentally and laboratorially. The study proved that acute surgical pathology in patients with moderate surgical risk is accompanied by the maintenance of a normal total volume of fluid with a significant redistribution of water sectors in the body such as plasma deficiency with development of hypovolemia, formation of intracellular dehydration, the initial increase in the volume of the interstitial space. The change in water sectors is combined with the development of relative hyperdynamia due to an increase in the total peripheral resistance and heart rate. The use of a restrictive strategy of infusion therapy in patients with moderate surgical risk allows restoring the physiological volumes of water sectors in the body and forms a normodynamic type of circulation from day 3 of postoperative period.*

Keywords: *restrictive protocol; liberal protocol; perioperative infusion therapy; water sectors; central hemodynamics; emergency laparotomy*

Introduction

Urgent surgery may be associated with a significant rate of complications, many of which are avoidable. Perioperative complications strongly correlate with long-term mortality and morbidity and generate increased healthcare costs. The average complication rate may vary from 5 to 64 %, and mortality rates are high, too (30–80 %) [3–6]. Fluid administration before, during and after abdominal surgery is an essential part of postoperative care to maintain the fluid and biochemical balance in a patient. Abdominal surgical procedures are associated with dehydration, bowel preparation and intra- and postoperative fluid and electrolyte loss [2]. Concerns about perioperative fluid deficiency, support of circulation and cardiac function after general anesthesia, control of postoperative circulation, avoidance of blood transfusion and preservation of urine output are all issues that are thought to account for the administration of these excessive amounts of fluid [1–4]. Liberal or traditional intravenous fluid regimens that are administered during abdominal surgery deliver up to 7 liters of fluid on day

of surgery. Such regimens can lead to tissue edema and weight gain of 3 to 6 kg. Some small trials have shown that a more restrictive fluid regimen led to fewer complications, a shorter hospital stay, and recent consensus statements support fluid restriction. Another concept has recently been raised that perioperative restrictive fluid therapy, also referred to as a near-zero perioperative fluid balance or a zero-balance approach, may be beneficial [5].

The purpose of the study was to compare the effectiveness of the restrictive and liberal protocol of perioperative infusion therapy in patients undergoing emergency laparotomy.

Materials and methods

Having agreed with the local ethics committee and obtained the informed consents, 100 patients were examined (46 men and 44 women with an average age of 60 ± 11 years). Acute cases of emergency laparotomy were: strangulated inguinal hernia ($n = 16$), strangulated ventral hernia ($n = 18$), acute intestinal obstruction ($n = 20$), perforated gastric ulcer ($n = 28$), perforated ulcer of the duodenum ($n = 10$), peritonitis ($n = 8$).

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Inclusion criteria: the patient's age more than 45 years and less than 75 years; emergency laparotomy; predicted intraoperative blood loss less than 500 ml; American Society of Anesthesiologists (ASA) III; diabetes mellitus in the stage of compensation.

Exclusion criteria: the patient's age less than 45 years and more than 75 years; gastrointestinal bleeding; ASA I–II–IV; diabetes mellitus in the stage of decompensation; pregnancy and lactation; allergic reactions to any component of drug therapy; patient's refusal to participate in the study.

All patients were examined according to the protocol of the Ministry of Health of Ukraine No. 297 (02.04.2010). At the same time, concomitant pathology was identified: ischemic heart failure ($n = 46$), diabetes mellitus type II in remission ($n = 12$), chronic bronchitis in remission ($n = 24$), excessive body weight (obesity class I–II) ($n = 21$), community-acquired pneumonia ($n = 4$).

Preoperative treatment was carried out in the intensive care unit according to the standards of professional protocols (Ministry of Health of Ukraine, 2008): perioperative fluid management, prevention of thrombosis and wound infections. Hypovolemia was managed using infusion balanced crystalloid solutions. To determine the severity of hypovolemia, we used the test of tissue hydrophilicity by Shelestiuk which corresponded to degree II. Patients were divided into two groups by blinding. In group 1 ($n = 50$), liberal regimen of fluid administration was applied perioperatively. Infusion volume was 80–120 ml/kg/day. Patients of group 2 ($n = 50$) received treatment of hypovolemia according to restrictive regimen — 40–60 ml/kg/day. Thus, 25 % of the calculated amount of volume deficit were infused during the first hour of treatment. In the absence of hemodynamic effects of infusion, we administered vasopressors (norepinephrine, phenylephrine) under general principles. Next 25 % were infused during two hours of treatment (including intraoperative). Full restoration of volume deficit (last 50 %) was carried out by the end of the first day of treatment. After a complete volume restoration, infusion therapy was performed under general principles.

Surgical intervention was performed with the total intravenous anesthesia in both groups. The average duration of the operation was 60.6 ± 20.3 minutes.

We studied the clinical parameters of systemic hemodynamics: blood pressure, mean arterial pressure, heart rate (HR) and routine clinical laboratory tests (general blood and urine analysis, coagulogram, biochemical blood test). The central and peripheral hemodynamic parameters (cardiac index (CI), general peripheral vascular resistance (GPVR)) were determined by the method of integral rheography using Diamant apparatus. The following indicators of water sectors were studied: the volume of extracellular fluid (ECF), the volume of intracellular fluid, the total volume of fluid, plasma volume by the method of noninvasive bioelectric integral evaluation of the body structure using the Diamant monitor complex.

ASA and POSSUM (Physiological and Operative Severity Score for the enUmeration of Mortality and morbidity) scales were used for stratification of surgical risk.

Postoperative complications were assessed according to Clavien-Dindo classification (2009). Control points: before surgery, 1, 3, 5–7, 10–14, 28–30 days after surgery.

The observation was conducted in accordance with the requirements of the ethical committee. Statistical processing of the results was carried out using the MS Excel 2007, Statistica 6 software package. The data are presented in the form $M \pm m$. P-values lower than 0.05 were statistically significant.

Results and discussion

The analysis showed an initial reduction of intracellular fluid and plasma volumes by 4.0 ± 0.2 % and 5.0 ± 0.2 % below norm in group 1 and 4.3 ± 0.1 % and 5.2 ± 0.3 % in group 2, respectively, in patients undergoing emergency laparotomy before the infusion correction. It corresponded to degree II of dehydration and was associated with an increase of ECF by 6.0 ± 0.1 % and 6.1 ± 0.2 %, respectively, in groups 1 and 2. The total volume of liquid saved was within the normal range. Relative hyperdynamia (CI exceeded normal values by 11.0 ± 0.8 % and 13.0 ± 0.6 %) was supported by vasospasm (GPVR was higher than norm by 18.0 ± 1.3 % and 19.0 ± 1.4 %, respectively, in groups) and tachycardia (HR was higher than norm — by 13.0 ± 1.5 % and 12.0 ± 1.8 %). It maintained the blood pressure at the level of norm.

After preoperative infusion therapy with balanced crystalloid solutions in a total volume of 2870 ± 540 ml according to liberal protocol of infusion therapy and 1733 ± 340 ml — to restrictive protocol during 2 hours, we noted a further increase in the incidence of heart failure in groups — to 9.0 ± 1.0 % and 8.0 ± 1.0 % above the norm, respectively, restoration of plasma volume and ECF to normal values against a background of increased total volume of fluid — by 4.0 ± 1.4 % and 2.5 ± 1.1 % of normal rates. In that time, restoration of volumes in water sectors was accompanied by stabilization of indices of central hemodynamics up to normodynamics with preservation of moderate tachycardia.

Patients of group 1 had the general volume of infusion of 6360 ± 450 ml in the first postoperative day. Water sectors did not differ from those before laparotomy, however, we marked a relative hypodynamia of circulation (CI — 78 % of the norm), increased GPVR — by 62 % of the norm, HR — by 26 % and mean arterial pressure maintenance about physiological norm. From day 3 to 7 of observation, hypodynamic type of hemodynamics was saved. The most expressed vasospasm was on the third postoperative day (GPVR is 66 % higher than norm) and remained to day 10. It combined with development of hypodynamic type of circulation on day 5 of observation, when the CI decreased by 24 % of normal level.

On day 1 of observation, the total infusion volume in patients of group 2 amounted to 4360 ± 450 ml. The volumes of water sectors did not differ significantly from those by the end of the preoperative infusion preparation, we noted the formation of a normodynamic type of blood circulation (CI corresponded to 98 % of the norm), GPVR was higher than norm by 2 %, and the preservation of blood pressure values occurred within the physiological norm. On the third postoperative day, water sectors in the body did not differ significantly from the normal values. It lasted until the end of the follow-up. From day 3 to 14 of treatment, the parameters of central hemodynamics also corresponded to the norm.

Conclusions

1. Acute surgical pathology in patients with moderate surgical risk is accompanied by the maintenance of a normal total volume of fluid with a significant redistribution of water sectors in the body:

- deficiency of plasma with the development of hypovolemia;
- formation of intracellular dehydration;
- an initial increase in the volume of the interstitial space.

2. The change in water sectors is combined with the development of relative hyperdynamia due to an increase in the total peripheral resistance and heart rate.

3. The use of a restrictive strategy of infusion therapy in patients with moderate surgical risk allows restoring the physiological volumes of water sectors in the body and forms a normodynamic type of circulation from day 3 of postoperative period.

Conflicts of interests. Authors declare no conflicts of interests that might be construed to influence the results or interpretation of their manuscript.

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Периоперационная инфузионная терапия разными по объему протоколами у пациентов со средним хирургическим риском, подлежащих неотложной лапаротомии

Резюме. С целью оценки эффективности либерального и рестриктивного протоколов периоперационной инфузионной терапии при неотложной лапаротомии нами было обследовано 100 больных. Степень операционно-анестезиологического риска соответствовала ПЕ классу по шкале ASA, хирургического риска по шкале POSSUM — 1–5 % (средний риск). Всем больным проведена предоперационная подготовка на протяжении 2 часов в условиях отделения интенсивной терапии в объеме 2870 ± 540 мл в 1-й группе и 1733 ± 340 мл во 2-й, при расчетной инфузионной нагрузке 80–120 мл и 40–60 мл/кг/сут соответственно. Больные были обследованы клинически, инструментально и лабораторно. В исследовании доказано, что острая хирургическая патология у пациентов со средним хирургическим риском сопровождается исходным

сохранением нормального общего объема жидкости на фоне дефицита объема плазмы с развитием гиповолемии, внутриклеточной дегидратации и интерстициального отека. Это приводит к относительной гипердинамии путем увеличения общего периферического сопротивления и частоты сердечных сокращений. Применение рестриктивной стратегии периоперационной инфузионной терапии позволяет восстановить физиологические объемы водных секторов организма и сформировать нормодинамический тип кровообращения с 3-х суток послеоперационного периода.

Ключевые слова: рестриктивный протокол; либеральный протокол; периоперационная инфузионная терапия; водные сектора; центральная гемодинамика; ургентная лапаротомия

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Періопераційна інфузійна терапія різними за обсягом протоколами в пацієнтів із середнім хірургічним ризиком, які підлягають невідкладній лапаротомії

Резюме. З метою оцінки ефективності ліберального та рестриктивного протоколів періопераційної інфузійної терапії при невідкладній лапаротомії нами було обстежено 100 хворих. Ступінь операційно-анестезіологічного ризику відповідав ПЕ класу за шкалою ASA, хірургічного ризику за шкалою POSSUM — 1–5 % (середній ризик). Усім хворим проведено передопераційну підготовку впродовж 2 годин в умовах відділення інтенсивної терапії в об'ємі 2870 ± 540 мл у 1-й групі та 1733 ± 340 мл у 2-й, при розрахунковому інфузійному навантаженні 80–120 та 40–60 мл/кг/добу відповідно. Хворі були обстежені клінічно, інструментально і лабораторно. У дослідженні доведено, що гостра хірургічна патологія в пацієнтів із середнім хірургічним ризиком

супроводжується початковим збереженням нормального загального об'єму рідини на фоні дефіциту об'єму плазми з розвитком гіповолемії, внутрішньоклітинної дегідратації та інтерстиціального набряку. Це приводить до відносної гіпердинамії шляхом збільшення загального периферичного опору судин і частоти серцевих скорочень. Застосування рестриктивної стратегії періопераційної інфузійної терапії дозволяє відновити фізіологічні об'єми водних секторів організму і сформувати нормодинамічний тип кровообігу з 3-ї доби післяопераційного періоду.

Ключові слова: рестриктивний протокол; ліберальний протокол; періопераційна інфузійна терапія; водні сектори; центральна гемодинаміка; ургентна лапаротомія